

**HUMAN SPACE FLIGHT  
FISCAL YEAR 1998 ESTIMATES  
BUDGET SUMMARY**

**OFFICE OF SPACE FLIGHT  
PAYLOAD AND UTILIZATION OPERATIONS**

**SUMMARY OF RESOURCES REQUIREMENTS**

<a href="#">Payloads and Utilization Operations</a>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>
<a href="#">Spacelab</a>	86,700	50,300	14,200
<a href="#">Tethered satellite system</a>	1,800	--	--
<a href="#">Payload processing and support</a>	40,600	41,700	51,600
<a href="#">Advanced projects</a>	24,200	34,700	58,700
<a href="#">Engineering and technical base</a>	169,700	148,600	102,900
<b>Total</b>	<b>323,000</b>	<b>275,300</b>	<b>227,400</b>

<b>Distribution of Program Amount by Installation</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>
Johnson Space Center	96,400	90,700	98,700
Kennedy Space Center	88,600	72,500	58,900
Marshall Space Flight Center	118,300	96,300	53,800
Stennis Space Center	1,600	1,700	1,400
Langley Research Center	300	300	500
Goddard Space Flight Center	9,500	7,300	7,600
Headquarters	8,300	6,500	6,500
Total	323,000	275,300	227,400

**PROGRAM GOALS**

The primary goals of the Payload and Utilization Operations are to support the processing and flight of shuttle payloads, to ensure maximum return on the research investment, to reduce operations costs, to continue to implement flight and ground systems improvements, and to

support strategic investments in advanced technology needed to meet future requirements.

### **STRATEGY FOR ACHIEVING GOALS**

The principal areas of activity in Payload and Utilization Operations include the operation of the Spacelab systems; cooperative reflight of the U.S./Italian Tethered Satellite System (TSS); Payload Operations for accommodating NASA payloads; Advanced Projects; and the preservation of an Engineering and Technical Base (ETB) capability at the human space flight centers. The activities of these programs are accomplished by civil service and contractor personnel. Over the past several years, NASA has been extremely successful in reducing processing time and error rates while increasing customer satisfaction and controlling cost. NASA will continue to implement operational efficiencies gained to date, plus assume additional efficiencies from elimination of duplicative activities, and from accepting minor risk increases by eliminating some testing and analysis during payload processing. Workforce reductions achieved to date have not impacted schedule time and the FY 1998 strategy includes plans to further reduce the workforce while maintaining or continuing to improve customer satisfaction.

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### **SPACELAB**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b>(Thousands Of Dollars)</b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Spacelab	86,700	50,300	14,200

### **PROGRAM GOALS**

Spacelab is a versatile, reusable, cost-effective observatory and laboratory facility located in the Space Shuttle payload bay. Spacelab supports a wide variety of science and technology development experiments which are developed by the utilizing programs within NASA and other external organizations. Spacelab serves as both an observatory and a laboratory, giving scientists the opportunity to conduct a large variety of scientific experiments in the unique environment of space.

### **STRATEGY FOR ACHIEVING GOALS**

Ten foreign nations, including nine members of the European Space Agency (ESA), participated in the joint Spacelab development program with NASA. The ESA designed, developed, manufactured and delivered the first set of Spacelab hardware which consisted of a pressurized module, five pallets, subsystem support hardware (e.g. igloo, Instrument Pointing Subsystem (IPS), racks, avionics, computers) and much of the ground support hardware and

flight and ground software.

Spacelab is configured within the orbiter bay in numerous ways to accommodate scientific experiments in the unique environment of space. "Hands on" experiments requiring astronaut participation use the pressurized module configuration. Experiments not requiring a pressurized environment, or requiring visual access to space, use the unpressurized pallet configuration. The module is pressurized and thermally-controlled to enable astronauts to work in a "shirt sleeve" environment. Easy crew access from the orbiter middeck to the module is enabled by the Spacelab tunnel. Module missions largely consist of life and microgravity sciences experiments.

Spacelab pallet missions are designed to accommodate up to five pallets in the orbiter bay, depending on the experiment requirements. In the event the experiment requires the use of the Spacelab computers and other avionics hardware which must be protected from the space environment, the igloo is used to house the hardware and is flown as an attachment to the pallet. Other pallet configurations include the Spacelab pallet system (SPS). One configuration supports missions requiring the use of the Spacelab computer system and pallet in a mixed cargo configuration (i.e., more than one major payload flown in the orbiter bay rather than a single major payload flown using the igloo subsystem).

Spacelab operations support is comprised of mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, systems operation support, payload operations control support, payload processing, logistical support and sustaining engineering. Support software and procedures development, testing, and training activities are also included in NASA's funding request. The Spacelab operations cycle is repeated with each Spacelab flight, but with a different payload complement. This cycle consists of two processing integration steps. Spacelab Level IV processing performs the integration and checkout of the experiment equipment with individual experiment mounting elements like racks, rack sets, and pallet segments, and is funded by the payload sponsor. This activity is normally performed at the Kennedy Space Center (KSC) but is not part of the Spacelab operations budget. Spacelab Level III/II processing then combines and integrates all experiment mounting elements such as racks, rack sets and pallet segments, which have the experiment equipment already installed and ready for checkout with the Spacelab software. This processing activity is also performed at KSC and is funded under the Spacelab budget.

Spacelab operations also funds smaller secondary payloads like the Get-Away Specials (GAS) and Hitchhiker payloads. The GAS payloads are research experiments which are flown in standard canisters that can fit either on the sidewall of the cargo bay or across the bay on the GAS bridge. They are the simplest of the small payloads with limited electrical and mechanical interfaces. Approximately 138 GAS payloads have been flown. The Hitchhiker payloads are the more complex of the smaller payloads, and provide opportunities for larger, more

sophisticated experiments. The Hitchhiker system employs two carrier configurations: (1) a configuration on the orbiter payload bay sidewall and (2) a configuration across the payload bay using a multi-purpose experiment support structure (MPESS). During the mission, the Hitchhiker payloads can be controlled and data can be received using the aft flight deck computer/standard switch panels or from the ground through the payload operations control center (POCC).

Payload analytical integration is the responsibility of the Payload Projects Office at the Marshall Space Flight Center (MSFC), and is supported by a contract with McDonnell-Douglas. Physical payload integration and processing is the responsibility of the Payload Management and Operations Office at the KSC, and is also supported by a contract with McDonnell-Douglas.

Another item funded in Spacelab operations is the Flight Support System (FSS). The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS is used on the Hubble Space Telescope (HST) repair/revisit missions.

The last Spacelab flight is scheduled for early 1998, with the advent of the more permanent science laboratory flown by the International Space Station (ISS). In FY 1998, Spacelab operations funding for GAS, Hitchhiker payloads and the FSS will be transferred to the Payload Processing and Support budget.

## **MEASURES OF PERFORMANCE**

<b><u>Spacelab Missions</u></b>	<b><u>Plan</u></b>	<b><u>Actual</u></b>
United States Microgravity Laboratory (USML-2)	September 1995	October 1995
Tether Satellite System Reflight (TSS-1R)	February 1996	February 1996
United States Microgravity Payload (USMP-3)	February 1996	February 1996
Life/Microgravity Sciences (LMS-1)	June 1996	June 1996
Microgravity Science Laboratory (MSL-1)	March 1997	--
United States Microgravity Payload (USMP-4)	October 1997	--
Space Life Sciences Laboratory-4 (Neurolab)	March 1998	--

	FY 1996	FY 1996	FY 1997	FY 1997	FY 1998
<u>Flight Hardware Utilized</u>	<u>Plan</u>	<u>Actual</u>	<u>Plan</u>	<u>Revised</u>	<u>Plan</u>
Long Module	1	2	1	1	1
Multi-Purpose Experiment Support Structures (MPESS)	1	1	--	--	1
Pallets Plus MPESS	2	1	--	--	--
Hitchhiker Experiments	9	9	11	14	5
Get Away Special Payloads	15	15	TBD	2+TBD	2+TBD
<u>Contractor Workforce</u>					
KSC (McDonnell-Douglas)	254	240	253	228	73
MSFC (McDonnell-Douglas)	192	165	160	158	62

## **ACCOMPLISHMENTS AND PLANS**

In FY 1996, the Spacelab program flew the following manifested missions: United States Microgravity Laboratory (USML-2) module mission, the Tether Satellite System Reflight (TSS-1R), United States Microgravity Payload (USMP-3), the Life and Microgravity Sciences (LMS) module mission, fifteen GAS payloads and nine Hitchhiker experiments.

Regarding FY 1997 activities, the Spacelab program will integrate and process Spacelab missions consistent with the Shuttle manifest including the Microgravity Sciences Laboratory (MSL-1) mission, as well as 14 Hitchhiker payloads and several GAS payloads. The mission to reservice the Hubble Space Telescope (HST SM-2) will utilize the flight support system (FSS). Efforts will be increased during the fiscal year to prepare for the Spacelab program phase-down (excluding the Hitchhiker, GAS and FSS programs), hardware/software disposition, final program flight in March 1998 and closing of the high bay in the Operations and Checkout facility presently projected for late FY 1998.

In FY 1998, the Spacelab program will process and integrate USMP-4 mission and the Neurolab module mission. Following the Neurolab mission, the final Spacelab program phasedown will occur, including disposition of hardware and software and closing the high bay in the Operations and Checkout facility. Because the Spacelab program is being terminated in FY 1998, the Hitchhiker, GAS and FSS programs are being transferred to the Payload Processing and Support program. In FY 1998 and subsequent years, significant reductions in both laboratory support and civil service workforce will occur from discontinuing the Spacelab program.

## **TETHERED SATELLITE SYSTEM**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b><u>(Thousands of Dollars)</u></b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Tethered satellite system reflight	1,800	--	--

### **PROGRAM GOALS**

The goal of the Tethered satellite system reflight (TSS-1R) program is to study the electro-dynamics behavior of the satellite-tether-orbiter system as it interacts with the charged particles and electric and magnetic fields within the Ionosphere, and to complete verification of the capability and utility of a Space Shuttle-based tethered satellite system (TSS).

### **STRATEGY FOR ACHIEVING GOALS**

The TSS was a cooperative program with Italy to provide a reusable space facility that would conduct space experiments at distances up to 100 kilometers from the Space Shuttle Orbiter while being held in a fixed position relative to the Orbiter. During the demonstration mission flown in August 1992, the TSS verified its capability to provide a dynamically stable research facility, but a mechanical interference in the deployment system prevented full deployment of the tether and satellite and completion of the science mission. In response to an Italian Space Agency request to reflly the mission, NASA conducted a reflight study, including an independent assessment of NASA's future use of tethered satellites. The study concluded that a reflight mission could be readily accomplished and recommended several improvements to enhance the probability of success. The independent assessment identified a number of significant and unique science and engineering objectives which can be accomplished using tethered satellites, and urged the continued development and utilization of the tethered technology. NASA agreed to reflly the TSS-1 mission in February 1996.

NASA was responsible for overall program management, systems engineering and integration, orbiter integration, ground and flight operations, development of the deployment mechanism and provision of the non-European instruments (Office of Space Science funded). NASA made substantial cost reductions in FY 1995 and FY 1996 by using in-house Marshall Space Flight Center personnel to perform the TSS-1R integration and operations. Italy was responsible for the design and development of the satellite and the European instruments flown on the joint mission. The United States Air Force sponsored one of the TSS-1R investigations.

### **MEASURES OF PERFORMANCE**

	<u>Plan</u>	<u>Actual</u>
Independent assessment of mission readiness	1st Qtr 1996	4th Qtr 1995
Launch TSS-1R	February 1996	February 1996
De-integrate TSS-1R	April 1996	June 1996
Post Mission Report	May 1996	August 1996
Complete Science Data Analysis	June 1997	--

## **ACCOMPLISHMENTS AND PLANS**

In FY 1996, the TSS-1R program completed integrated mission simulations, conducted an end-to-end communications test of the flight operations configuration, installed the payload in the Shuttle, and held flight readiness reviews. The TSS-1R mission was launched on STS-75 in February 1996. After being deployed to a distance of 19.7 kilometers, the tether broke and the satellite was lost. An independent review panel investigated the in-flight failure of the tether system and found the tether failed due to electrical arcing between the tether and deployer causing the burning and subsequent failure of the tether. Despite the incident, data gathered prior to the failure is expected to accomplish a majority of the science objectives. After completion of the TSS-1R mission, the remaining hardware was de-integrated and project phase-out began. Activity planned for completion in FY 1997 includes mission and science data analysis, hardware storage and decommissioning, future mission studies in accordance with the NASA/Italian MOU, and documentation archiving.

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## **PAYLOAD PROCESSING AND SUPPORT**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b><u>(Thousands of Dollars)</u></b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Payload processing and support	40,600	41,700	51,600

## **PROGRAM GOALS**

The primary goal for payload processing and support is to provide the capability to safely and efficiently assemble, test, checkout, service, and integrate a wide variety of Space Shuttle spacecraft and space experiments.

## **STRATEGY FOR ACHIEVING GOALS**

The payload processing and support program provides the technical expertise, facilities and

capabilities necessary to perform: payload buildup; test and checkout; integration and servicing of multiple payloads; transportation to the launch vehicle; and integration and installation into the launch vehicle. Included in this program are operational efficiencies gained to date, as well as additional anticipated efficiencies to reduce cost and improve customer satisfaction. Efficiencies already in place have reduced processing time and error rate. Funding from additional realized operational savings was transferred to Advanced Projects for the X-38 program in FY 1997 and to Engineering and Technical Base for Advanced Space Transportation Program requirements in

FY 1998. Due to the termination of the Spacelab program in FY 1998, the Hitchhiker, Get Away Special (GAS) and Flight Support System (FSS) program will become part of the Payload Processing and Support program in FY 1998.

### **MEASURES OF PERFORMANCE**

	<u>FY 1996</u>	<u>FY 1996</u>	<u>FY 1997</u>	<u>FY 1997</u>	<u>FY 1998</u>
<u>Missions Supported</u>	<u>Plan</u>	<u>Actual</u>	<u>Plan</u>	<u>Revised</u>	<u>Plan</u>
Space Shuttle Missions	7	8	7	7	7
Spacelab Payloads	4	4	1	1	2
Hitchhiker Experiments	9	9	11	14	5
Get-Away Special Payloads	15	15	TBD	2+TBD	2+TBD
Mir Missions	3	3	3	3	2
Other Major Payloads	4	4	5	5	5
Other Secondary Payloads	2	2	1	--	--
Expendable Launch Payloads	9	8	7	10	8
<u>Number of Payload Facilities Operating at KSC</u>	6	6	6	6	6
<u>KSC Payload Ground Operations (PGOC) Workforce</u>	362	361	359	360	360

### **ACCOMPLISHMENTS AND PLANS**

The FY 1996 funding provided payload processing and support for eight Space Shuttle missions, as well as the necessary customer payload processing facilities and support for 37 major and secondary payloads. Among the payloads processed in FY 1996 include United States Microgravity Laboratory (USML-2), three Shuttle Mir missions (S/MM-2, 3 and 4), Space Flyer Unit Retrieval (SFU-RETR), Tethered Satellite System Reflight (TSS-1R), United

States Microgravity Payload (USMP-3), SPARTAN 207/IAE, OAST FLYER, Spacehab-4, and Life and Microgravity Spacelab (LMS). Payload processing facility support was provided to ELV payloads such as Near Earth Asteroid Rendezvous (NEAR), Solar Heliospheric Observatory (SOHO), and X-ray Timing Explorer (XTE). These payloads are provided by American industries and universities, and also in cooperation with our international partners. The reflight of the Italian Tethered Space Satellite (TSS-1R) was a major payload involving international cooperation. Work was completed on the refurbishment of the instrument and control system and the environmental control system of the payload canister and transporter (used for transporting payloads at KSC). Consistent with the Agency's reduction of its infrastructure, NASA transferred the Cape Canaveral Air Force Station Hangar AO facility to the Air Force in January 1996.

In FY 1997, Payload Processing and Support will furnish launch and landing payload support for seven Shuttle missions, as well as payload processing facilities and support for 25 major and secondary payloads. The payloads to be processed in FY 1997 include Orfeus-Spas-2, Wake Shield Facility (WSF-3), Microgravity Science Laboratory (MSL-1), Shuttle Mir missions ((S/MM-5, 6 and 7), Hubble Space Telescope Servicing Mission (HST-SM-2), Crista-Spas-2 and Manipulator Flight Demonstration (MFD). Payload processing facility support will be provided to ELV payloads such as Advanced Composition Explorer (ACE), GOES-K, Mars Pathfinder, and Mars Global Surveyor (MGS).

In FY 1998, Payload Processing and Support will furnish launch and landing payload support for seven Shuttle missions, as well as payload processing facilities and support for 16 major and secondary payloads. Among the payloads to be processed are U.S. Microgravity payload (USMP-4), Neurolab, Spartan 201-04, Advanced X-Ray Astrophysics Facility (AXAF), Shuttle Mir missions ((S)MM-8, 9), Alpha Magnetic Spectrometer (AMS), two International Space Station (ISS-01-2A, 02-3A) assembly flights, and several secondary payloads. Payload processing facility support will be provided to ELV payloads such as New Millenium Deep Space-I and Cassini. The Hitchhiker, GAS, and FSS programs will be transferred to this budget from the discontinued Spacelab program.

### **ADVANCED PROJECTS**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b>(Thousands of Dollars)</b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Advanced projects	24,200	34,700	58,700

### **PROGRAM GOALS**

The primary goals of the program are to mature technologies to enhance crew safety for the

Space Shuttle and Space Station, to implement flight and ground systems improvements to substantially reduce cost of Space Flight operations, and to pursue advanced technology developments to meet future Human Space Flight requirements. Secondary goals of the program are to promote transfer of advanced technologies and to develop a fully capable, diverse and motivated workforce. The Advanced Projects activity includes five program elements: Advanced Development and Operations, Advanced Space Systems, Advanced Extravehicular Activity (EVA) Systems, Telerobotics Research and Technology, and the X-38 demonstration program.

## **STRATEGY FOR ACHIEVING GOALS**

The Advanced Development and Operations program supports projects which improve ground and flight operations of current and future Human Space Flight vehicles by identifying, advocating and demonstrating available technologies and processes which are more efficient, cost-effective, reliable, have dual use potential, and meet safety and performance requirements. The projects are developed to a prototype level to validate their objectives within three years. Successfully demonstrated projects are transitioned to an operational program for implementation and to private enterprise for commercial development.

Several Advanced Operations projects have been jointly funded, either in their development or commercialization, by other government agencies such as the Department of Energy, and the State of Florida, as well as by private industry, via cooperative agreements or Space Act Agreements. The Advanced Operations program places a high priority on leveraging its limited funds through partnerships with other fund sources, public and private, to achieve its goals.

The Advanced Space Systems program includes the Orbital Debris program and a series of flight demonstration experiments to validate critical advanced technologies in a relevant environment. The Orbital Debris effort supports projects which improve the safety of the Space Shuttle and the Space Station by measuring, modeling, and mitigating the orbital debris environment. In addition, the Orbital Debris activity includes an international cooperative program, jointly funded by the space agencies of Russia, Japan, China and the European Space Agency, which seeks to develop a common understanding of the debris environment. This program also develops common practices for protecting spacecraft and mitigating the orbital debris environment. The Flight Demonstration program identifies and demonstrates available technologies and processes which are efficient, cost-effective, reliable, and meet safety and performance requirements. Projects are matured to a protoflight level, utilizing existing carriers as test beds for developing space flight hardware and operational processes to ensure their readiness to meet operational requirements. Flight demonstrations also includes training for young NASA engineers and managers with early "hands-on" flight hardware experience.

For safety reasons, a Crew Return Vehicle (CRV) is necessary for permanent human

habitation of the International Space Station. The X-38 experimental vehicle is specifically designed to demonstrate the technologies and processes required to produce a CRV in a "better, faster, cheaper" mode. Evaluation of the performance of the technologies of the X-38 systems are conducted through a series of ground, air, and space tests. Based on the U.S. Air Force/Martin-Marietta X-24A lifting body research vehicle, successful demonstration of the X-38 technologies will lead to a final CRV configuration for implementation on the International Space Station. Through cooperative arrangements which are under discussion with the European Space Agency, the DOD, and the Japanese Space Agency, NASA will also seek to find and develop commonality between the CRV and other space vehicles.

The primary goals of the Advanced EVA program are to perform the scientific research and engineering development needed to mature technologies that enhance EVA crew safety, reduce EVA operational cost and enhance capabilities to meet future space flight requirements. The Advanced EVA research and development program includes research and development to reduce the operational impact of decompression sickness, while increasing safety via better understanding of the science involved. The research and development roadmap includes tasks to address environmental protection, EVA mobility, electronics integration, and EVA system integration with other space systems. The Advanced EVA program is conducted using a mix of ground based simulation and flight testing to prove the development approach. After four years of ground-based research and development, the program concludes with a three-year task to demonstrate on-orbit the new EVA technologies from a systems point of view. The program actively seeks partnering with industry and other government agencies as well as transfer of technology into the program from outside sources to accomplish the needed technology development.

The Telerobotics Research and Technology program includes research and development of telerobotics technologies to improve crew efficiencies and capabilities for the Human Exploration and Development of Space, including the International Space Station and Space Shuttle. Telerobotics research includes areas such as EVA assistant, dexterous manipulators, sensing and processing, mobility systems, human interfaces, and other related telerobotics technologies. The telerobotics program is conducted through ground and flight research and demonstrations to prove the viability of each technology approach. The Telerobotics Research and Technology program was transferred to the Advanced Projects Office during FY 1997, from the former Office of Space Access and Technology.

## **MEASURES OF PERFORMANCE**

The success of the Advanced Projects activities has been, and will continue to be, measured by the success of its projects. Over 100 projects have been supported in the past six years, most of which have been successful in delivering products that enhance the efficiency and reduce the cost of ground and flight operations. Many of the advanced technologies incorporated in the new integrated Shuttle/Station Mission Control Center were developed in this program. These

technologies are contributing to a significant reduction of Space Flight mission operations costs. The following events represent significant milestones in the successful completion of this program:

### Advanced Operations

Performance Milestone	Plan	Actual/Revised	Description/Status
Migrate Mission Information System and Electronic Documentation System to the MCC	1st Qtr FY 1996	1st Qtr FY 1996	Provides paperless documentation capability to the MCC and flight support offices at the Johnson Space Center, to remote payload support offices, and to the flight vehicle. Both tools are now in routine use in the MCC
Deliver on-board training system for STS-76/Mir mission demonstration	3rd Qtr FY 1996	3rd Qtr FY 1996	Demonstrates the capability to provide contingency and proficiency training for crews via laptop computer during long-duration missions.
Demonstrate Electronic Documentation System on-board STS-76/Mir	3rd Qtr FY 1996	3rd Qtr FY 1996	Extends the "paperless" flight document capability now available in the Mission Control Center to the flight vehicle enabling more efficient document update during long-duration missions as well as reduced publication costs.
Complete Advanced Training "walk-in" virtual environment	3rd Qtr FY 1996	3rd Qtr FY 1996	Demonstrates state-of-the art training technique which could improve efficiency and reduce cost of total immersion training previously provided by simulators and water tanks.

In the Orbital Debris activity, accurate measurements have been made of the orbital debris environment. Models have been developed to predict the changes in the environment as a function of time. Utilizing these measurements, flight rules, operational procedures, and new orbital debris protection systems have been developed and/or modified to improve/enhance safety during Shuttle and Space Station operations. To date, a total of 16 successful flight demonstrations have been flown. All of these demonstrations achieved their primary technical objectives. All of the flight demonstration projects that are currently under development have been manifested. Future milestones include:

## Advanced Space Systems

Performance Milestone	Plan	Actual/Revised	Description/Status
Static Feed Electrolyzer (SFE) Flight Demonstration Critical Design Review	1st Qtr FY 1996	3rd Qtr FY 1996	This flight demonstration will validate the microgravity sensitivity of key SFE subsystem components on an integrated basis. An operational SFE would reduce the annual resupply weight for the International Space Station by 12,000 pounds with an associated reduction in logistics costs. The CDR was delayed in FY 1996 due to lack of final design maturity.
International Space Welding Experiment (ISWE) Cargo Integration Review	1st Qtr FY 1997	Under Development	The ISWE will demonstrate the ability to perform contingency repairs to the International Space Station using an electron beam welding device developed by the Paton Institute in the Ukraine.
Orbital Debris Collector (ODC) Returned from Mir	4th Qtr FY 1997	--	The ODC is an experiment to collect <i>in-situ</i> samples of the micro debris environment from the orbit of the International Space Station to understand the sources of this debris and thus enabling effective steps to mitigate it.
Students for the Exploration and Development of Space Satellite (SEDSAT) Delivery to KSC	4th Qtr FY 1997	--	Delivery of SEDSAT satellite for testing and integration.
Students for the Exploration and Development of Space Satellite (SEDSAT) Launch	4th Qtr FY 1997	--	Deployment of SEDSAT as a DELTA II secondary payload. SEDSAT will serve as an amateur radio relay system and will collect multi-spectral remote sensing data.

SFE Flight Demonstration	1st Qtr FY 1998	Under Development	This flight demonstration will verify the performance capability of the SFE subsystem in microgravity during the STS-87 mission. This flight demonstration was redirected at the request of Space Station. A new oxygen generation experiment is planned.
International Space Welding Experiment (ISWE) Flight Demonstration	1st Qtr FY 1998	Under Development	The capability of the Ukrainian Universal Hardware to perform contingency repairs on the International Space Station will be demonstrated during the STS-87 Mission. The ISWE project has been recently demanifested to accommodate the reflight of the EVA Development Flight Test (EDFT) program on STS-87. An alternative flight manifest opportunity for ISWE is under review.

## X-38

Performance Milestone	Plan	Actual/Revised	Description/Status
Atmospheric Test Program	4th Qtr FY 1997	--	Five atmospheric test flights of Vehicles 131 and 132 conducted to demonstrate full lifting body control and parafoil control systems.
Begin initial Space Vehicle (201) Construction	4th Qtr FY 1997	--	Construction of the first (201) space vehicle will be initiated. Primary structure (cabin and aft fuselage) will be fabricated, most subsystems installed and ready for integrated test, and some aeroshell panels with thermal protection system will be completed.

## Advanced EVA Research and Development

<b>Performance Milestone</b>	<b>Plan</b>	<b>Actual/Revised</b>	<b>Description/Status</b>
Gloves ready for flight tests	2nd Qtr FY 1997	3rd Qtr FY 1998 & 3rd Qtr FY 1999	Demonstrates on-orbit performance of gloves which incorporate increased mobility features and better thermal protection.
Soft space suit configuration hardware delivery	2nd Qtr FY 1998	--	Delivery of new soft space suit for testing. Soft suits hold potential of being lighter weight and easier to stow.
Soft space suit configuration comparison test delivery	3rd Qtr FY 1998	--	Demonstrates the amount of mobility that can be incorporated into a soft suit configuration.
Radiator ready for test	3rd Qtr FY 1998	--	Demonstrates on-orbit cooling using a radiator instead of water sublimation in the real thermal environment.

### **Telerobotics Research and Technology**

<b>Performance Milestone</b>	<b>Plan</b>	<b>Actual/Revised</b>	<b>Description/Status</b>
Free-Flying Camera Robots for EVA	4th Qtr FY 1997	--	Implement upgrades to the existing Supplemental Camera and Maneuvering Platform (SCAMP) system.
Robotics Technologies for ISS Maintenance	2nd Qtr FY 1997	--	Testing of remote surface inspection systems.
	4th Qtr FY 1997		Evaluation of calibrated synthetic viewing.
	4th Qtr FY 1997		Performance of robotic control technologies

testing, and transitioned operations to the Mission Control Center, extended its capabilities to other NASA Centers, and demonstrated its use on-board the Shuttle. Second, the Advanced Training Technologies (ATT) project demonstrated the capability to provide contingency and proficiency training in orbit via laptop computer, and demonstrated a "walk-in" virtual environment to provide total immersion training now done in simulators and water tanks. One of the products of the ATT project was named NASA Invention of the Year for 1995, and its project manager received the 1995 American Management Society award for outstanding technical management. Third, the Cooperating Expert Systems (COOPES) project completed development and certification of vehicle system monitoring expert systems and information sharing software tools for the Mission Control Center. The project received a Federal Leadership Award and a Space Act Award during

FY 1995 for development of the Information Protocol. Fourth, the Conductive Polymer Coating Space Act Agreement received the final installment in its 3-year commercial development process. The corporate, university and government laboratory partners plan to complete testing of the coating and have it ready for market in 1998. Beginning in FY 1997, this successful program will be transitioned to the Space Shuttle program to help meet its cost reduction goals.

Also in FY 1996, an Advanced Development effort was initiated to mitigate risk for the future development of a crew return vehicle and other applications. Industry has been briefed on the X-38 program status and how the design of the Space Station CRV will

be based on the design and technologies demonstrated on the space flight test articles of the X-38 program. An industry procurement competition for the operational Space Station CRV flight vehicle production is scheduled to take place in late FY 1997. By pursuing a rapid prototype technology demonstration effort, the X-38 program will validate critical technologies required to support the development of an operational Space Station CRV resulting in substantially reduced development costs for this capability, while providing a cost effective opportunity to validate technologies for other future space flight requirements. The X-38 project is an effort to reduce the cost of a crew return vehicle (CRV) for the International Space Station by developing and flight-testing critical technologies for the vehicle. The effort is an in-house, civil servant effort focused on design studies, computer analysis, subsystem component testing and limited in-flight demonstrations. The resulting operational CRV is to be produced by industry utilizing the technologies advanced by NASA. Particular emphasis is placed on technologies that have the potential to reduce design and operational costs for the vehicle. This activity will continue through FY 1999.

The X-38 program will continue to measure subsystem and system performance throughout FY 1997. A key element of the plans include completion of the Atmospheric Test program in which two vehicles (131, 132) will be drop-tested from a B-52 to prove a mix of lifting body and parafoil systems and flight modes. Construction of the first space vehicle (201) will be

nearly complete during FY 1998. The Aft Fuselage, Outer Skin and Thermal Protection Systems (TPS) will be completed and the first de-orbit module will be delivered. Integrated testing of vehicle 201 will also begin in FY 1998.

In the Advanced Space Systems program a total of 16 successful flight demonstrations have been conducted. Some examples of recent accomplishments follow:

The second phase (hardware development phase) of the International Space Welding Experiment (ISWE) with the Paton welding Institute (PWI) in Ukraine was successfully initiated. A phase 2 (hardware development) contract with PWI was negotiated for the delivery of two sets of universal hardware as well as a work station. Design and fabrication of the flight universal hardware and the work station were completed early in FY 1997. Delivery of the flight universal hardware occurred in FY 1996 and the flight workstation was delivered in early FY 1997.

The Orbital Debris program is directed at measuring the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability techniques. Additional hours of observations of the debris environment were collected in FY 1996 using the Haystack Orbital Debris Radar bringing the total to over 5000 hours. Additional measurements of the environment were obtained from numerous Shuttle missions providing invaluable data on the nature of the micro-debris environment and its damage potential to manned spacecraft. The liquid metal mirror telescope was moved to Cloudcroft, New Mexico. Visual observations of debris particles as small as 10 centimeters in geostationary orbit are possible using this telescope. The Orbital Debris Radar Calibration Spheres (ODERACS-2) flight demonstration was flown on the Space Shuttle. ODERACS-2 successfully deployed three spheres and three dipoles which were used to calibrate the Haystack Orbital Debris Radar, optical telescopes and other radars used to characterize the orbital debris environment.

In FY 1997 and FY 1998, the Haystack Auxiliary Radar and the Haystack Radar will continue to monitor the orbital debris environment for the Space Station. Orbital debris will continue to focus on characterizing changes in the orbital debris environment as a function of time and on establishing measures for mitigation of debris growth trends. An international geostationary debris observing program will be initiated with participation from NASA, ESA, Russia, Japan, Australia, and other spacefaring nations. Work will begin on the design of an Extra Vehicular Activity (EVA) debris shield for protecting the Space Station crews when they are exposed to the debris environment during an EVA.

In FY 1997, Advanced Projects will support the AERcam/Sprint flight experiment, a robotic "flying eye" for visualization and inspection of science and Space Station payloads.

The Debris Capture experiment will be returned from the Mir station after approximately one

year in orbit. Analysis will begin of the debris samples captured by the aero gel.

The ISWE flight demonstration will achieve launch readiness early in FY 1998, but a flight date aboard the Space Shuttle remains to be determined.

In FY 1997 and FY 1998, the Advanced EVA Research and Development program will start research to address the mechanisms which control decompression sickness in a zero gravity environment. Research into better protection for EVA operations in the space environment will also be initiated. The design efforts for space suits which are predominantly built with soft elements and a portable life support system which uses cryo oxygen will be initiated.

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### **ENGINEERING AND TECHNICAL BASE**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b><u>(Thousands of Dollars)</u></b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Engineering and technical base	169,700	148,600	102,900

### **PROGRAM GOALS**

The focus of the Engineering and Technical Base (ETB) is to support the institutional capability in the operation of space flight laboratories, technical facilities, and testbeds; to conduct independent safety, and reliability assessments; and to stimulate science and technical competence in the United States. ETB activities are carried out at the Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and Stennis Space Center (SSC). ETB provides the underpinning of the Centers' performance of research and analysis and testing tasks, to solve present problems, and to reduce costs in developing programs, technologies, and materials.

### **STRATEGY FOR ACHIEVING GOALS**

The Office of Space Flight (OSF) strives to sustain its institutional technical base and preserve a high degree of core capability and excellence. Since FY 1994 the four OSF centers have consolidated activities and have identified ways to economize the resources committed to ETB while maintaining ETB's benefits to the nation's human space flight program. Over the next few years, this consolidation will continue to generate savings in information resources management and contract streamlining. A prioritized core environment will be dedicated to multi-program labs and test facilities, associated systems, equipment, and a full range of skills capable of response to research, testing and simulation demands.

As the ETB budget is reduced, several activities will be continued to refine current business

practices. Mandatory equipment repair and replacement will be reassessed. Software applications for multi-program analytical tools will be implemented. Strategy to better manage the NASA investment in information processing resources will include aggressive actions to integrate and consolidate more ADP operations. ETB will ensure synergism among major NASA engineering programs. Awards for education and research tasks will be granted to support educational excellence and research learning opportunities in colleges and universities. A key component of the ETB strategy will be to provide a core capability for future human space flight endeavors with fewer resources. Future budget constraints dictate that new innovative processes be adopted to meet critical ETB core requirements, and that non-critical capabilities be streamlined or eliminated.

## **MEASURES OF PERFORMANCE**

<b>Performance Milestone</b>	<b>Plan</b>	<b>Actual/Revised</b>	<b>Description/Status</b>
Laboratory facilities (KSC)	--	--	Continuing Support for 22 labs for approximately 121 applied research projects
Laboratory facilities (JSC)	--	--	Continuing support for science and engineering laboratories
Laboratory facilities (MSFC)	--	--	Continuing support for approximately 50 core laboratory areas
Propulsion Facility and Lab Facilities (WSTF)	--	--	Continuing provision of core environment to support customer base

Information resource management (IRM) Five Year Investment Plan (MSFC)	4th Qtr FY 1996	4th Qtr FY 1997	Consolidate ADP Operations of the other Field Centers to the supercomputer. Ames Research Center is in charge of the initiative. A draft schedule is currently being reviewed, but this will be an on-going effort through FY 1997.
NASA Minority University Research and Education Program at JSC, KSC, MSFC & SSC	--	--	Award education and research grants

## ACCOMPLISHMENTS AND PLANS

The institutional technical base accomplished numerous activities in FY 1996. At JSC, ETB funded the purchase of laboratory equipment and technicians, engineering workstations, calibration equipment and services, component fabrication, and Class VI computer maintenance and operations in support of the science and engineering laboratories and facilities at JSC. This ETB support ensures that JSC retains the capability to perform real-time mission analysis of flight anomalies and real-time and post-flight problem resolutions, as well as other science and engineering testing and analysis. In addition to laboratory support, ETB supports safety, reliability, and quality assurance (SR&QA) activities for the Space Shuttle and Space Station programs. JSC also continued to award ETB research grants to Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs).

At WSTF, FY 1996 ETB funding supported the propulsion testing facility and other

understanding and properly using fiber optics for launch processing. The ETB supported upgrades to the LC-39 measurement system. The ETB also participated in the development of landing aids for a lightning warning and prediction system, as well as development of toxic vapor detectors and sensors to measure vapors from the Space Shuttle tile waterproofing compound. In addition, ETB supports KSC's Life Sciences tasks.

The MSFC allocation of ETB funds supports approximately 50 core laboratory areas. ETB support enables the Center's technical core capability to provide in-depth technical support for designs, developments, testing, mission operations and evaluation of Launch Vehicles, Space Transportation Systems, Space Stations, and Payloads. ETB enables MSFC to conduct research and development efforts related to advanced propulsion systems and spacecraft, as well as engineering design, systems engineering, systems integration, material and process engineering, physical science research, test and evaluation, data analysis and system simulations. As the NASA Center of Excellence in propulsion systems, in FY 1997, MSFC is continuing to support the Advanced Space Transportation Technology Program, whose ultimate objective is to make dramatic reductions in the cost of boosting payloads into low-Earth orbit. Funding in the amount of \$12.0 million is identified to continue development of low-cost, small booster technologies and demonstration of rocket-based combined cycle (RBCC) propulsion hardware. Effort on low-cost small booster technologies will include avionics hardware, engine component hardware (injector, chamber, turbomachinery, valves, actuators, ducts and lines), test support and propellants for component testing. RBCC activities include test hardware fabrication, test support and propellants. Continuation of these activities after FY 1997 has been transferred to the Aeronautics and Space Technology program.

At SSC, ETB supports the SSC technical core laboratory operations, and will fund initial operations for the Component Test Facility (CTF) in FY 1997. CTF will play a central role in making the Stennis Space Center the Center of Excellence for propulsion testing. The SSC laboratories perform activities for the Space Shuttle program, reimbursable resident governmental agencies and the CTF test operations. The SSC core laboratory environment provides customers with gas and material analysis, non-destructive evaluations, standards and calibrations, environmental analysis, fluid component processing, maintenance and fabrication of welded structures and components, and machining and fabrication of mechanical structures and components. ETB also enables SSC to complete advanced planning studies involving cost trade presentations for future facility utilization and technology development tasks such as the seal configuration tester prototype. ETB also funds sensor development for engine health management and for spectral analysis.

The ETB program includes the institutional Safety and Mission Assurance (SRM&QA) contractor workforce performs space flight activities at JSC, WSTF, MSFC and KSC. This workforce includes highly skilled personnel who are charged with responsibility to conduct assessments of conformance to reliability and quality standards. In FY 1996, surveillance of design, manufacturing and testing of hardware and software was conducted to ensure

compliance with NASA safety and mission assurance requirements. The ETB resources will support independent assessments of flight and test equipment and testing operations, including product assurance tasks for the International Space Station program (ISS). However, product assurance tasks and funding for the ISS will be transferred to the Office of Safety and Mission Assurance in FY 1998.

Information resource management (IRM) processing achieved efficiencies and improved economies of scale through the consolidation of IBM-compatible mainframes supporting administrative and programmatic automated data processing (ADP) services at the NASA ADP Consolidation Center located at MSFC. Consolidation of user requirements and information technology plans were implemented at JSC, MSFC, SSC and Headquarters. The NASA Automated Data Processing (ADP) Consolidation Center (NACC) provides supercomputing capability for its customers for engineering and scientific computer-intensive applications 7 days a week. The NACC supercomputing facility was established in FY 1994 and is managed through the MSFC NACC Project Office. The NACC supercomputing facility includes a mainframe located at MSFC and a smaller distributed system located at JSC.

The NACC supercomputing customers are from JSC and MSFC. The NACC supercomputer facilities include hardware and software to conduct thermal radiation analyses, computational fluid dynamics, structural dynamics and stress analyses for NASA programs such as the Space Shuttle, X-33, X-34, Space Station, and Reusable Launch Vehicle. The facilities also conduct certification and engineering performance evaluation of flight and test data. In the past, supercomputing at both JSC and MSFC was funded through ETB at the individual Centers. The NACC supercomputing facility is funded through ETB and programmatic funding from the participating supercomputer customers beginning in FY 1996. During FY 1997, MSFC and JSC will continue to develop and process software applications under the new funding arrangements.

In cooperation with the goals of the NASA Minority University Research and Education Program, ETB enables the space flight Centers to participate in programs to stimulate science and technical competence in the Nation. The ETB program enabled the Centers to award education and research grants to Historically Black Colleges and Universities (HBCU), Other Minority Universities (OMU), Teacher/Faculty enhancement programs, and JSC University Research Program. MSFC awarded a total of 52 grants in FY 1996. Examples of awards granted include solution crystal growth in low gravity; organic fiber optic sensors; hydrazine solution disposal; atmospheric corrosion sensor; properties of ion beam deposits, and phytoalexins in plant disease.

In FY 1998, the ETB budget will continue to implement reductions resulting from the Agency's zero-base review. These reductions will result in a reduced level of science and engineering lab support to human space flight programs, streamlined technical operations, additional ADP consolidation activities, and reduced education and research awards funding.

These reductions will require that all Centers continue to assess their range of workforce skills, analytical tools and facilities dedicated to ensure space flight institutional engineering support for future human space flight programs and the existing customer base. This assessment will focus on maintaining core support for design, development, test and evaluations, independent assessments, simulation, operations support, anomaly resolution, and systems engineering activities with reduced funding. The operation and maintenance of the CTF will be supported, as will a variety of research and engineering laboratories. FY 1998 funding is significantly reduced from previous years due to the transfer of the development of low-cost small booster technologies and demonstration of rocket-based combined cycle (RBCC) hardware to the Advanced Space Transportation Technology program; the transfer of the International Space Station independent assessment function to the Office of Safety and Mission Assurance; and other infrastructure reductions at the Human Space Flight